Toward a Predictive Model of Arctic Coastal Retreat in a Warming Climate, Beaufort Sea, Alaska

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Award Number: N0001409WR20069
http://www.oc.nps.edu/~stanton/

LONG-TERM GOALS

The primary objective of my research is to study wave and turbulent processes acting in coastal, surf zone and high latitude settings. In the course of this research, I develop highly specialized instrument systems to measure the fluid motions that resolve both wave and turbulent motions, and the interaction of these motions with the fluid boundaries, for example with mobile beds in coastal regions. These observations are analyzed to seek simplified representations of the physics of these small scale processes in larger scale numerical models.

OBJECTIVES

The scientific objective of this collaborative effort is to measure the nearshore wave conditions along the North Alaska coastline in the late summer to understand changes in the wave field acting on the coastline as the summertime Arctic ice pack continues to retreat. This project crosses the two main themes of my research program – high latitude ocean/ice interactions during a period of ice retreat, and coastal wave processes. The primary hypothesis is that the significantly increased wave fetch in late summer – during the Beaufort Sea ice extent minimum – is strongly contributing to the observed rapid increase in coastal erosion of the permafrost bluffs that characterize this coastline. My University of Colorado collaborators have a concurrent, extensive field program measuring the coastal erosion rates along a 30Km stretch of this coastline for the last two years. My contribution to the larger project is to characterize the incident wave field in terms of the fetch-limited wave generation and cross-shelf wave propagation to define the wave fields and setup incident on the fragile coastal bluffs, and to help define the cross-shore structure of solar warmed shelf waters which provide the heat source for melting the permafrost cliffs.

APPROACH

Four high resolution, pressure-based, hand-deployable wave height sensor packages were assembled with buoyant tethers and small surface floats, that also supported tid-bit temperature sensors. The wave

Report Documentation Page						*Form Approved* *OMB No. 0704-0188*
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1. REPORT DATE **2009**		2. REPORT TYPE				3. DATES COVERED **00-00-2009 to 00-00-2009**
4. TITLE AND SUBTITLE **Toward a Predictive Model of Arctic Coastal Retreat in a Warming Climate, Beaufort Sea, Alaska**						5a. CONTRACT NUMBER
						5b. GRANT NUMBER
						5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)						5d. PROJECT NUMBER
						5e. TASK NUMBER
						5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Code OC/St, Department of Oceanography,833 Dyer Road,Monterey,CA,93943**						8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)						10. SPONSOR/MONITOR'S ACRONYM(S)
						11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT						
15. SUBJECT TERMS						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON	
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**		

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

sensor electronics continuously sampled the pressure signals at 4 Hz with 16 bit resolution, 1 in 10^9 GPS synchronized time stamp accuracy, and an endurance of over 150 days. To minimize logistic costs, the wave sensors were deployed by my collaborators from a coastal work boat during a cross-shelf bathymetry survey.

WORK COMPLETED

A 60 day observation of the cross-shelf wave field was made between and 30 July and 27 September 2009 by deploying the four wave sensors at 1.8m, 3.2m, 4.4m and 6.8m mean depth. Unfortunately the deepest wave sensor had a processor failure, but the other sensors all yielded stable, low noise pressure timeseries which have been processed into wave height spectra timeseries. An internal temperature sensor provides a near-bed temperature timeseries to compliment the temperature sensors deployed on the tether lines by my collaborators.

RESULTS

One hour averaged wave height spectral timeseries have been generated for the full timeseries for each of the three wave sensors, and the significant wave height and peak wave period extracted for each ensemble interval. An eight day example of the wave analysis for the inshore sensor is shown in Figure 1. During this time, three wind events occurred, producing significant wave heights approaching 1m at this shallow site. The low frequency signals of the pressure sensor reveal small tidal excursions, and significant, shelf–enhanced wind setup during some of the storms. The focus of on-going collaborative analyses is to assess the relative roles of the large fetch low peak frequency wave fields, the solar-warmed inner shelf waters, and high wave setup-wind events on accelerating erosion of the permafrost coastal bluffs. I will also be analyzing details of the cross-shelf spectral evolution of the wave field to study the impacts of the dissipative muddy seabed that is characteristic of the site.

IMPACT/APPLICATIONS

This study has important implications for coastal erosion in Arctic regions that have recently become exposed to energetic large fetch wind waves. The detailed geographic study undertaken by my University of Colorado colleagues will provide detailed measurements of the coastal bluff response to the observed local wave field.

RELATED PROJECTS

This wave observation and analysis is a small componentt of the main coastal erosionstudy undertaken by my University of Colorado colleagues

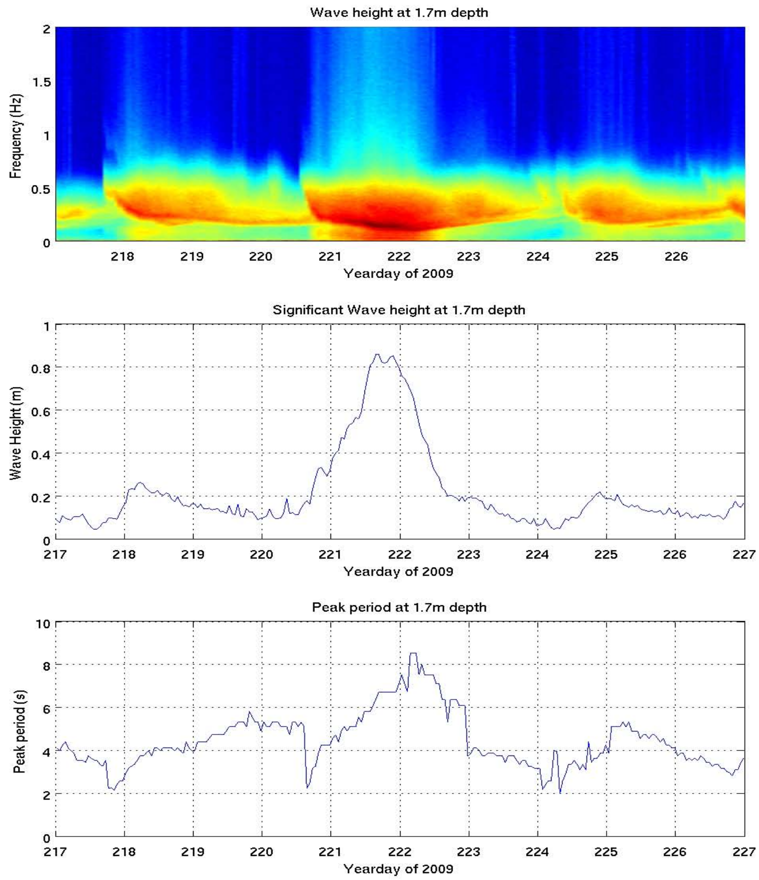

Figure 1. This 8 day timeseries of wave height spectral density (upper panel), significant wave height (middle panel) and wave peak period (lower panel) represents an example of the wave field observed at 1.8m mean depth by the inner-most wave sensor deployed on the North Alska Coast. During the second of three wind events, wave heights reached 0.8m with a peak period of 8 seconds. The cross-shore array of sensors is allowing the wave propagation and dissipation of the wave field incident on the coastal bluffs to be studied.